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ABSTRACT

The extent to which computer-aided drafting and design (CADD) was being used in local businesses in Saginaw, Michigan, was investigated. Focuses of a literature review were types of CADD systems, categories of CADD users, and the symbiotic relationship between industry and education in providing CADD training. The survey questionnaire was administered to drafter and designer employers who used CADD systems to design and detail mechanical and machine tool products. Twenty-seven of 34 questionnaires were returned. Six respondents who classified themselves architectural/civil were eliminated from the survey results; the remaining respondents were categorized into three groups: manufacturing/design/process engineering company, contract design drafting service, or other. Two-dimensional design/drafting was rated the highest use of CADD and having the highest need for inservice training. Digitizing drawings was rated the lowest use and the lowest need for training. The most used mainframe CADD system was Unigraphics. Currently employed CADD operators acquired skills to operate CADD systems on the job or in apprenticeships most often and in a high school setting least often. According to most respondents (62 percent), 76 to 100 percent of work was being done on CADD systems rather than to manual procedures. (The instrument, 20 endnotes, and 10 references are appended.) (YLB)

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AN INVESTIGATION INTO COMPUTER AIDED DRAFTING AND DESIGN (CADD) IN THE SAGINAW AREA FROM THE VIEWPOINT OF MECHANICAL DRAFTING AND DESIGN EMPLOYERS

by

John L. Irwin

U.S. DEPARTMENT OF EDUCATION
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Ferris State University

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CHAPTER I

THE PROBLEM

Introduction and Background

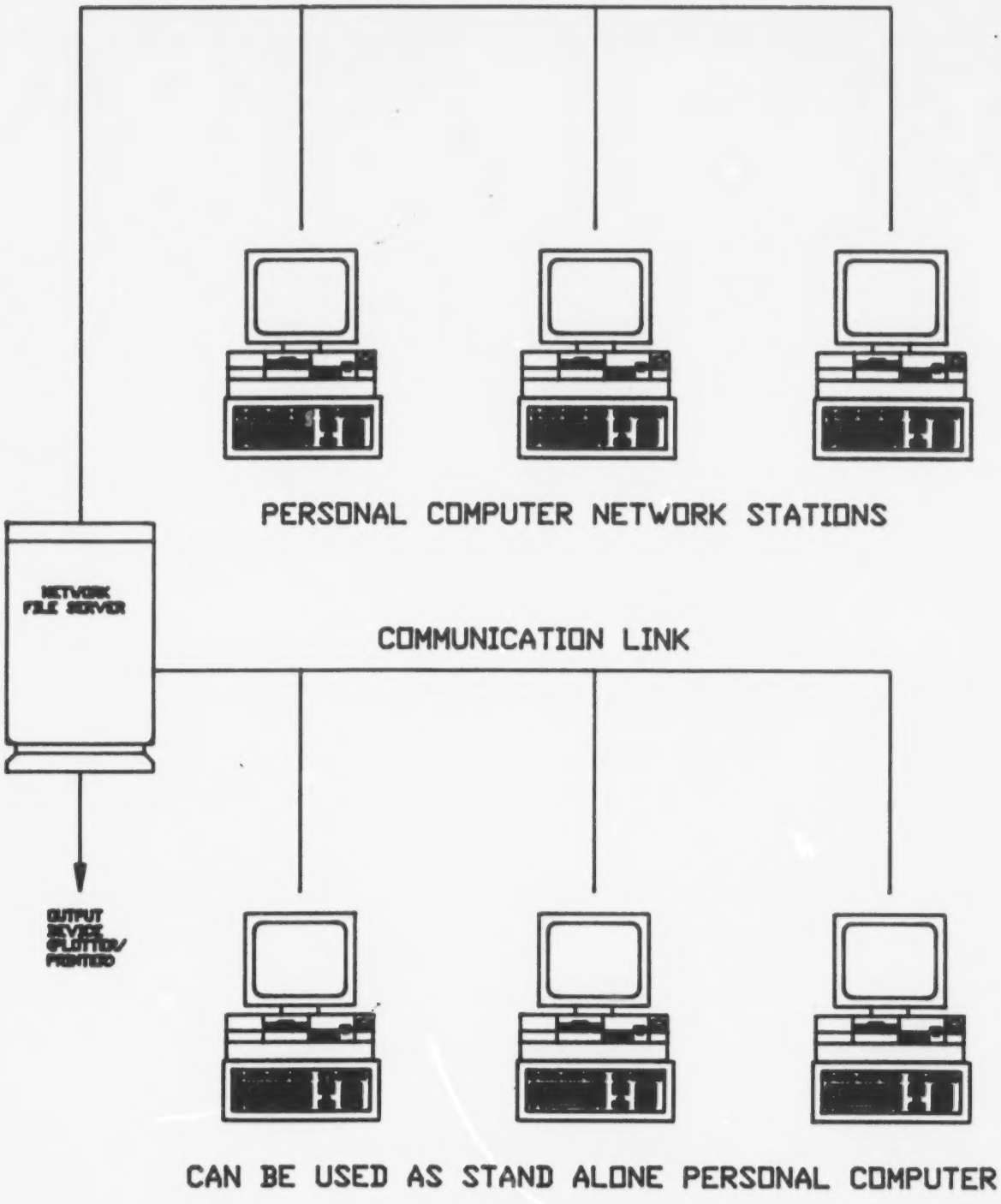
"The computer has become the principal tool at the drafter's workstation. It is replacing manual drafting tools such as drafting tables, pencils, scales, and templates."[1]

In 1987 the Averill Career Opportunities Center in Saginaw responded to the computer age by providing training on 5 CADD stations, and most recently in 1991 updating their facilities to encompass a networked 21 station AutoCAD system to provide training to high school and adult students. Other educational facilities in the area also train students on both mainframe and microcomputer CADD systems. CADD systems are being used by many local companies, since Saginaw is a highly industrialized area due to the automotive and chemical producing industries.

Projected growth of CADD systems made possible by the development and refinement of the integrated circuit has led to enormous expansion from 10,000 workstations in 1979 to over 250,000 in 1990.[2] CADD systems are classified as mainframe or microcomputer systems. The mainframe computer systems process information extremely fast, contain a vast amount of storage capacity, and can solve complex engineering problems. These systems consist of a large main computer with many separate terminals (workstations) that

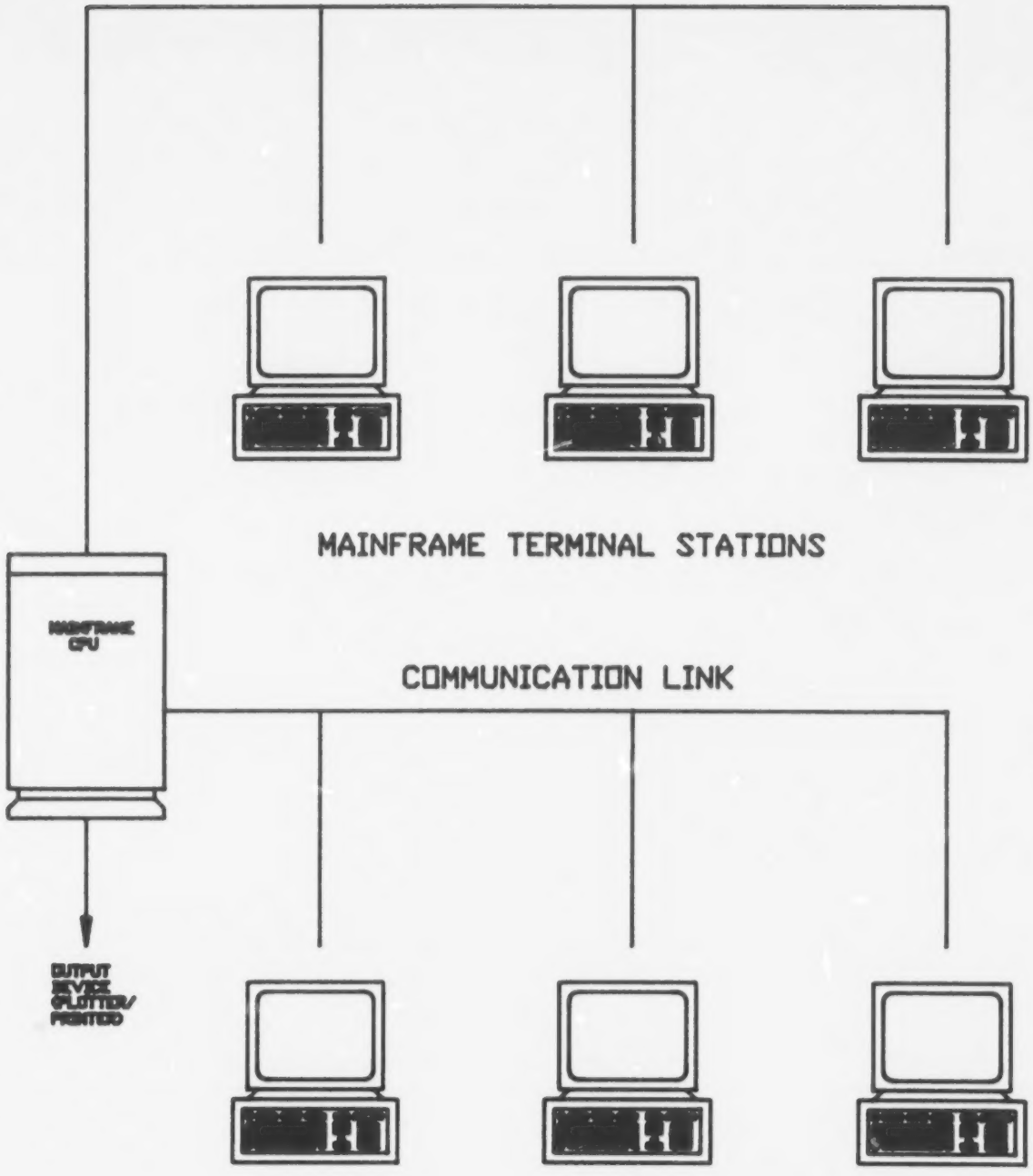
access the main computer memory (Figure 1). Microcomputer systems are similar to mainframe systems except each computer can function as a stand-alone system, or they can be networked allowing users to share information (Figure 2).

The cost of a mainframe computer is extremely expensive to purchase, lease, and maintain, and a high degree of computer and drafting experience is necessary to effectively use a mainframe system.[3] On the other hand microcomputers are fairly inexpensive costing about 1/10 the amount of a mainframe workstation. The different types of CADD software are too numerous to mention, and are continuing to improve in their expansion of three dimensional options, and now experimental programs even allow drafters to input graphic commands by voice actuation.


PERSONAL COMPUTER NETWORK STATIONS
NETWORK FILE SERVER
COMMUNICATION LINK
OUTPUT DEVICE PLOTTER/ PRINTER
CAN BE USED AS STAND ALONE PERSONAL COMPUTER

MAINFRAME SYSTEMS

FIGURE 1



MICROCOMPUTER SYSTEM

FIGURE 2

Statement of the Problem

The purpose of the study is to identify the extent to which computer aided drafting and design is being used in local businesses. Specifically, this study asked drafter and designer employers who use CADD how they utilize their particular system or systems.

The information obtained by this research will give the researcher a better understanding of the extent to which students should be trained in the use of CADD, and on what type of system they should be trained. The engineering field can utilize the results of this study for planning future possibilities for utilizing their particular CADD systems more effectively. The research may also uncover some areas of critical need for inservice training in CADD which could influence the types of courses being offered at vocational centers and junior colleges in the Saginaw area. Contract engineering firms who rely on outsourced work from independent companies will be interested in the results of the portion of the survey related to the percentage of CADD work being outsourced each year. Students interested in CADD will be able to utilize the information in the study as an aid in career choice with respect to the results of the CADD uses verses manual drafting procedures question.

Research Questions

1. What is the rank order list of CADD uses in the Saginaw area?

2. What type of microcomputer CADD softwares are being used in the Saginaw area?

3. What type of mainframe CADD systems are being used in the Saginaw area?

4. What are the primary methods that currently employed drafters/designers used to get CADD training?

5. What is the level of education of CADD drafters/designers in the Saginaw area?

6. What amount of CADD work is outsourced to contract services?

7. What are the inservice needs regarding CADD in the Saginaw area?

8. What amount of design and drafting is performed using CADD verses manual procedures?

9. What is the relationship between contract services and independent firms uses of CADD systems?

Definition of Terms

The following terms are defined to clarify their use in the context of the study:

1. Contract Service = A company which employs engineers, designers, drafters, and checkers to perform engineering tasks as a service for independent firms who do not have the time, personnel, or equipment to accomplish tasks on a timely basis.

2. Independent Firms = A company which has manufacturing, design, and process engineering, departments to eventually produce a usable product to be sold to a consumer.

3. CADD = Computer aided design and drafting performed on either a microcomputer or mainframe system.

Scope and Delimitations of the Study

This study was conducted in view of the following limitations:

1. The manufacturing field in the Saginaw area is very much competitive in the field of assembly and testing machines, which gives apprehension on the part of companies to allow any information out from behind closed doors concerning how they go about designing their products.

2. The outsourcing of work is also a subject of high confidentiality to companies in the design business.

3. Even the type of CADD system being used by a company is sometimes viewed as a company secret in order to give that company an edge over their competitor.

CHAPTER II

Review of Related Literature

Introduction

Computer Aided Drafting and Design is a relatively new technique to be used in the engineering field. Research related to CADD from the viewpoint of the CADD employers is limited. Many of the studies cited explain the importance for industry involvement in developing CADD training curriculums, but they are not surveys of the mechanical CADD employers like the one done in this research project.

The literature related to this study falls into the following three categories:

1. Types of CADD systems
2. The categories of CADD users
3. The symbiotic relationship between industry and education in providing CADD training.

Types of CADD Systems

In order to make training an advantage for local employers all works cited stress the importance in utilizing local CADD users and industrial advisory committees to assist in decisions about equipment needs. The funding of CADD equipment being solicited and granted by corporations is also a trend in all works cited.

In a 1985 study of Elgin Community College's 7-year history of program development and operation in cooperation

with Northern Illinois industries it is cited that low cost tuition is available due to the generosity of the Computer Vision Corporation.[4] Similarly, in a 1984 report on North Seattle Community College's integration of CADD into its Electro-Mechanical Drafting program it gives credit to the IBM Corporation for granting funds for CADD equipment.[5]

The comparison was made earlier in Chapter I between the low cost of personal computer systems and high cost of mainframe systems. So, it does not make sense to compare the prices of alternate systems unless the systems have similar capabilities. However, whatever the variation in cost between the two types of CADD systems, they all represent a considerably more significant outlay for users than the $2,000 per head of drawing equipment which backs draftpersons in traditional manual drafting situations.[6]

The major turnkey suppliers of mainframe CADD systems are Computer Vision, Applicon, Intergraph, Auto-trol, Unigraphics, and IBM CADDAM.[7] All of these systems were included on the survey used in this research except Auto-trol, which is not a popular system in the Saginaw area because it is mainly used in mapping.

Categories of CADD Users

This study is focused on the uses of CADD in the mechanical industries in the Saginaw area, because this researcher is a mechanical drafting instructor and mainly a mechanical CADD user. However, there are many different uses for CADD systems other than mechanical. "Currently the major

market is for mechanical systems where the penetration of CADD technology is low and the aggregate potential is high. A large potential also exists in the architecture, civil and structural engineering (ACE) fields, as well as in new fields such as retaining layout, business graphics and animation."[8]

Within the mechanical area there are many different levels of users as illustrated by a London report done in 1982, which investigates the feasibility of including CADD material in engineering courses. The report categorizes CADD users as system designers who provide CADD programs, specified users who use the system to design and do analysis, and naive users who use the system for detailing and sketching purposes.[9] The type of training for the three categories of user require post-graduate for system-designers, a formal degree for the specialized user, and a broad and descriptive training for the naive user.[10]

Mechanical CADD users fall into the category of technical workers who are the most highly educated and best trained of the nation's employees, and they receive their educations from school and employer-based formal and informal training.[11] CADD systems being a relatively new addition into the drafting field requires a high degree of individualized training to keep the technical professional up-to-date in his or her discipline. Statistics in 1985 show that in regards to upgrading skills for engineers 23 percent comes from schooling, 28 percent from employer-based formal

training, and 18 percent from employer-based informal training.[12]

Industry and Education

In a 1984 report on the subject of CADD training in industry and education it is stated that a symbiotic relationship between education and industry could increase the supply of trained operators of CADD equipment.[13] All literature cited stressed the importance for these relationships such as in the following quote: "Teachers need to maintain close contact with local industries to ascertain the real needs of employers."[14], but very few actually cited methods used to ascertain this information.

The reports which did explain how partnerships between employers and external training providers were formed fall into two categories which are known as connections and linkages. "Some examples of connections are employer representation on provider advisory boards, exchange of technical training equipment between employer and provider, and lending of expertise to help identify industrial applications of technology and design curriculum for training in those applications."[15]

In a report on the partnership between education and industry it is cited that one advantage to industry is that companies getting started in CADD can employ CADD students during off hours digitizing drawings to relieve designers and engineers of these tedious, but necessary tasks.[16] The advantages to the educational facility are establishment of

relevant course objectives and content, and laboratory experiences similar to the ones they would perform when working on a CADD system in industry.

The formation of linkages, on the other hand, are formal, contractual relationships between employers and training providers whose function is to provide occupationally specific training or retraining for employed technical workers.[17] A similar type of link was made during the development of a CADD program in 1984 where a link was established with allied vocational programs in the Seattle Public Schools, and a future curriculum and registration arrangement was made with Shoreline Community College in cooperation with major electronic and recruiting firms.[18]

Summary

The challenge to educators is to provide training to local companies who are CADD users in their own specific area of engineering. The task at hand is summed up in the following quote: "If we are to provide retraining to thousands of experienced designers and technicians, the education must equal or surpass that which is provided in-house or at the vendor schools."[19]

CHAPTER III

Methodology and Procedures

Introduction

To obtain answers to the questions of this study, (as stated in Chapter I), a survey questionnaire was used. This instrument was administered to drafter and designer employers who use CADD systems to design and detail mechanical and machine tool products.

Procedures

In order to achieve the objectives of this study companies needed to be identified, information based on their perceptions needed to be gathered, and the results analyzed and presented. The procedures were as follows:

1. Identification of companies
2. Gathering the data
    a. Development of the questionnaire
    b. Pretesting the questionnaire
    c. Revision of the questionnaire
    d. Administration of the questionnaire
3. Analyzing the data
4. Presenting the data

Identification of Companies

An initial list of companies was formed by researching the Saginaw area yellow pages under the subject headings of design, drafting services, engineering, and mechanical

industries. The list was then reviewed by the C.O.C. Engineering Computer Drafting Advisory Committee for possible additions or subtractions. The companies were limited to mechanical/machine tool companies and contract services in order to keep the research focused in one direction. Input from the Saginaw MESC office, Saginaw newspaper classified advertisements, and the local Society of Mechanical Engineers rounded out the list of some 30 to 40 companies to be surveyed.

Gathering the Data

The data necessary was gathered through the use of a questionnaire which was sent to all the companies to the attention of the CADD manager/user along with a letter of transmittal. The letter explained to the CADD manager/user that some information completed in the survey would probably need to be obtained from the personnel department.

Development of the Questionnaire

The questionnaire was patterned after a combination of similar questionnaires. The CADD uses portion in particular was patterned after a survey used by Lansing Community College.[20]

Revision of the Questionnaire

The questionnaire was pretested to the C.O.C. advisory committee, Saginaw, Michigan which consists of eight representatives from industry in Saginaw and an instructor from Delta College, Bay City, Michigan. Before administration the questionnaire was also evaluated by Joe

Fobear, Assistant Principal, Averill C.O.C., Jack Visuri, Co-op Coordinator, Averill C.O.C., and Dr. Ed Cory, Professor, Ferris State University, program advisor for this research project. Appropriate changes were made on the questionnaire following the pretest and evaluations, and a final version of the questionnaire was completed.

Administration of the Questionnaire

The questionnaire (appendix A) and letter of transmittal (appendix B) were sent to the thirty-four companies selected as subjects for the survey. The CADD managers/users were asked to return the questionnaire within 10 days after receipt. Three weeks after the first mailing, a follow-up letter (appendix C) and another copy of the questionnaire was sent to each of the companies who failed to respond.

Analyzing the Data

To achieve the reporting of data the portion of the survey on CADD uses was constructed in a manner which allowed coding of responses. The coded responses on this portion of the survey could be entered into a microcomputer to obtain frequency distributions, percentages, and other statistical data. The responses for the extent to which CADD is being used and the need for inservice training for CADD was rated on a numerical scale from 1 to 5. The use of a simple averaging technique gave a value for each CADD use which could then be rank ordered.

Similarly, the portion of the survey related to type of

CADD system being used, amount of work being outsourced, and amount of work done on CADD was numerically coded to allow percentages to be calculated on each of the responses. The respondents were asked to enter the total number of CADD personnel who received training on CADD in a specific educational setting and also a number to indicate the highest level of education earned by the CADD employee. These responses were tallied producing totals for where CADD training was being experienced, and levels of educational achievement.

Respondents who classified themselves in the category of architectural/civil were thrown out of the survey results. The remaining respondents were categorized in three groups depending on their response to whether they were a manufacturing/design/process engineering company, a contract design/drafting service, or other. The responses to the questionnaire were then separated into the two categories of independent firms and contract services. These two groups of statistics on CADD uses were compared using the chi-square formula in order to measure the contrast between the two groups.

Presenting the Data

The uses of CADD and the need for inservice were rank ordered in tables also including means and standard deviations for each CADD use response. Pie charts were used to illustrate the percentages of types of software being used, the amount of work being outsourced, and the amount

CADD is being performed as compared to manual methods. A histogram was used to illustrate the level of education and the method of training used to obtain CADD skills by the respondents. Data was compared in tables to illustrate the contrast of CADD uses by contract services verses independent firms.

CHAPTER IV

RESEARCH FINDINGS

Introduction

The purpose of this study is to identify the extent to which computer aided drafting and design is being used in local businesses. Specifically, this study asked drafter and designer employers who use CADD how they utilize their particular system or systems.

Most questionnaires were returned with each of the three sections completed. However, in three instances, the respondents did not return the section of the survey concerning CADD employee information on training and level of education. In the reported data on CADD training and level of education the percentages are based only on answers from the respondents who provided complete surveys.

Data from Questionnaire

Table 1 lists the description of the respondents. Most of the respondents (13, 48.1%) were those which described themselves as manufacturing/design/process engineering firms in the mechanical/machine tool area. The six respondents in the architectural/civil engineering area were not included in the analysis and presentation.

Table 1		
Frequency and Percent of Respondents (N=27)		
Firm Description	N	%
a.Manufacturing/design/ process engineering	13	48.1
b.Contract design/ drafting service	6	22.2
c.Architectural/civil engineering	6	22.2
d.Other (both a & b)	2	7.4
e.Non respondents	7	N/A

The majority (7, 53.8%) of the manufacturing respondents described their primary product as automated assembly, testing, or CNC equipment. Non respondents totaled 7, 20.6% of the 34 total surveys sent out.

What is the rank order list of CADD uses in the Saginaw area?

What are the inservice needs regarding CADD in the Saginaw area?

The responses to question 9, the extent to which CADD is being used and the need for inservice training for CADD, were rated on a numerical scale from 1 to 5. In Table 2 & 3 each CADD use is rank ordered according to the mean along with each corresponding standard deviation.

CADD USES			
RANK ORDER LIST OF THE EXTENT TO WHICH CADD IS BEING USED			
1 = ALWAYS 2 = USUALLY 3 = SOMETIMES 4 = RARELY 5 = NEVER			
RANK	CADD USES	MEAN	STAND. DEV.
1	2D DESIGN/DRAFTING	2.25	1.372
2	ELECTRONIC/HYDRAULIC/ PNEUMATIC SCHEMATICS	2.38	1.596
3	PROPOSAL DRAWINGS	2.40	1.273
4.5	3D DESIGN DRAFTING	3.30	1.525
4.5	ISOMETRIC DRAWINGS	3.30	1.418
6	BILLS OF MATERIAL	3.45	1.432
7.5	SOLID MODELING	3.90	1.518
7.5	CIM/CAM/CNC	3.90	1.447
9	DIGITIZING DRAWINGS	4.55	.826

TABLE 2

CADD USES			
RANK ORDER LIST OF THE NEED FOR INSERVICE TRAINING FOR CADD			
1 = CRITICAL 2 = VERY NECESSARY 3 = NECESSARY 4 = SOMEWHAT NECESSARY 5 = UNNECESSARY			
RANK	CADD USES	MEAN	STAND. DEV.
1	2D DESIGN DRAFTING	2.30	1.380
2	3D DESIGN DRAFTING	2.55	1.572
3	ISOMETRIC DRAWINGS	2.90	1.373
4	SOLID MODELING	2.95	1.432
5	ELECTRONIC/HYDRAULIC/ PNEUMATIC SCHEMATICS	3.14	1.459
6	PROPOSAL DRAWINGS	3.50	1.469
7.5	CIM/CAM/CNC	3.60	1.698
7.5	BILLS OF MATERIAL	3.60	1.465
9	DIGITIZING DRAWINGS	3.95	1.234

TABLE 3

What type of microcomputer CADD softwares are being used in the Saginaw area?

What type of mainframe CADD systems are being used in the Saginaw area?

The responses to question 5, the type of CADD systems and number of stations of each being used, were tallied and percentages were calculated. The results are shown in Figure 3.

TYPE OF CADD SYSTEMS IN USE
N=166

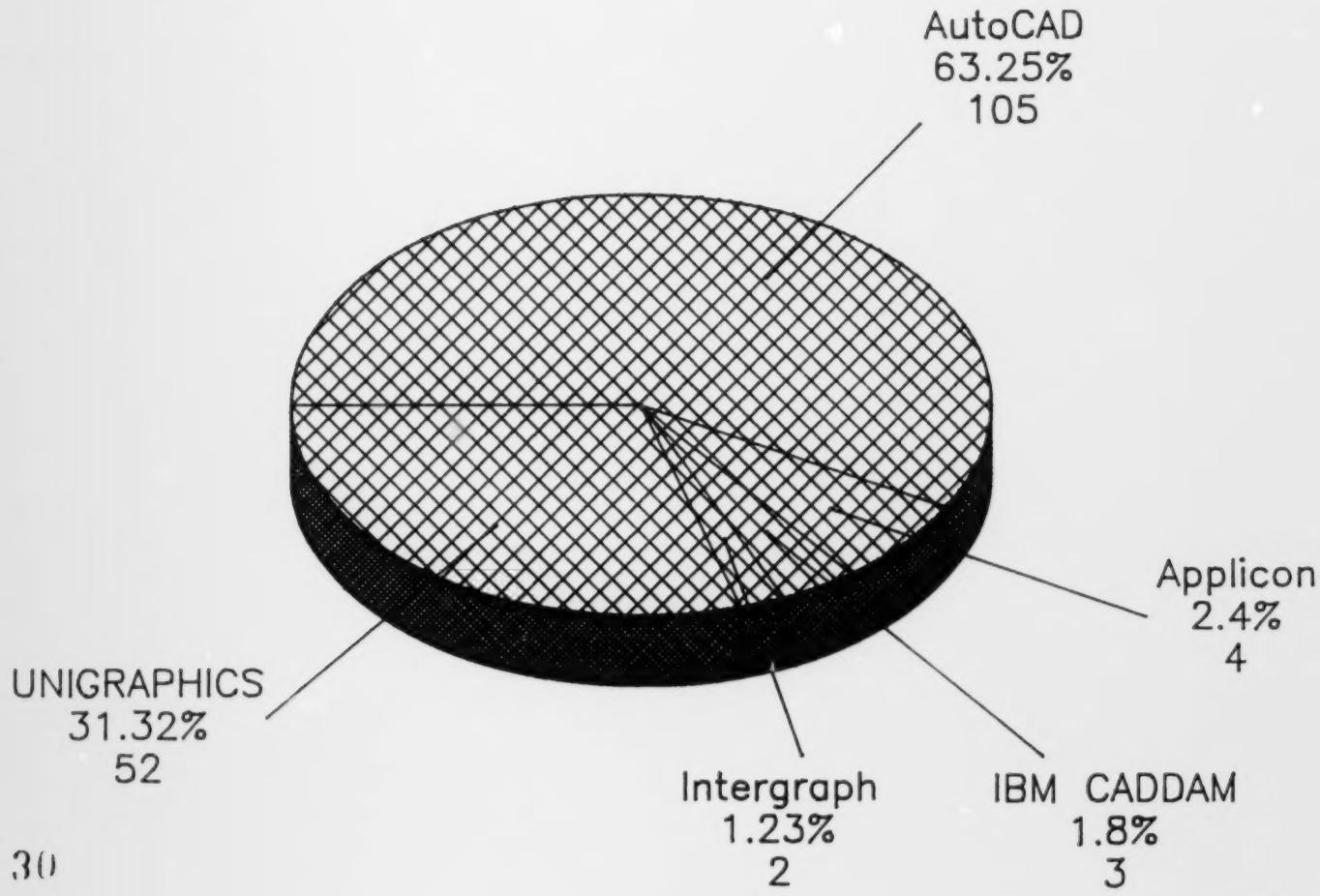


Figure 3

What are the primary methods that currently employed drafters/designers used to get CADD training?

What is the level of education of CADD drafters/designers in the Saginaw area?

The responses to question 8, training and level of education of CADD users, were tallied and frequencies were calculated. Figure 4 illustrates the method of training used to obtain CADD skills. Figure 5 illustrates the highest level of education achieved by CADD users.

METHOD OF TRAINING USED TO OBTAIN CADD SKILLS
N = 141

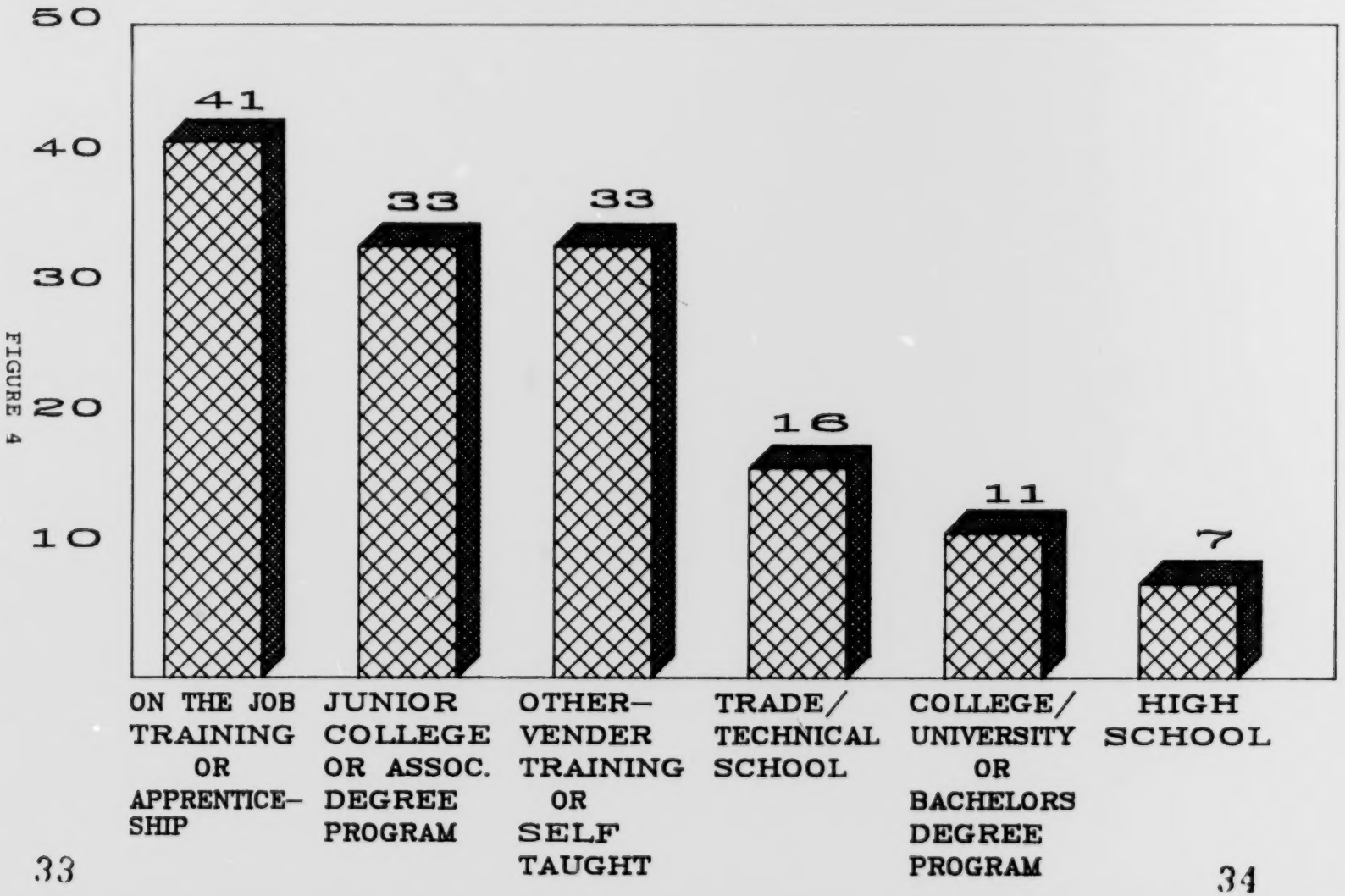


FIGURE 4

Irwin, 25

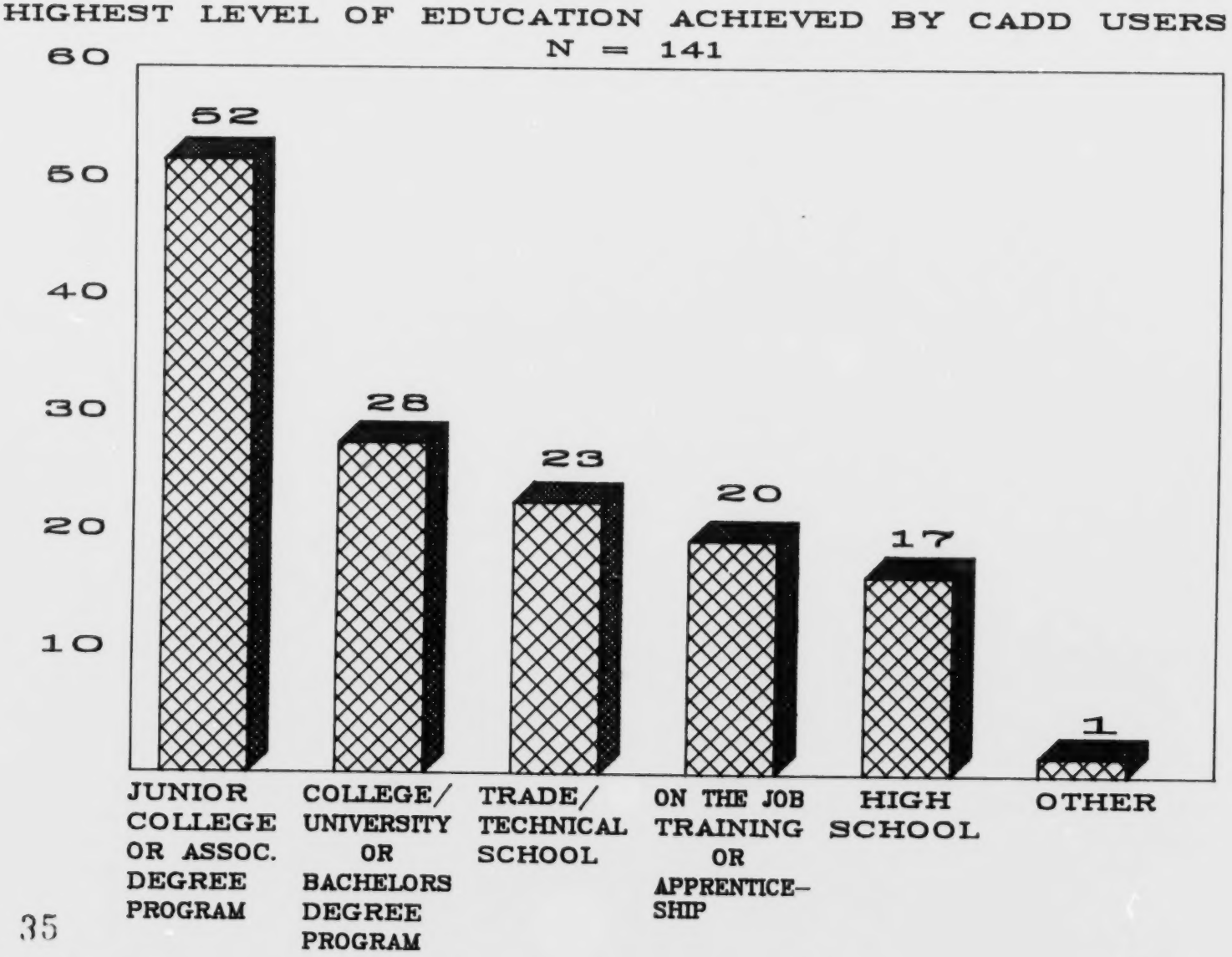


FIGURE 5

Irwin, 26

What amount of CADD work is outsourced to contract services?

What amount of design and drafting is performed using CADD verses manual procedures?

The respondents were asked in question 6 to rate the percentage of CADD work being outsourced in a five-value scale labeled none, 1 to 25%, 26 to 50%, 51 to 75%, and 76 to 100%. Similarly, the respondents were asked in question 7 to rate the percentage of design and drafting performed using CADD systems as compared to manual procedures. The information gathered is shown in Figures 6 & 7.

# AMOUNT OF WORK BEING OUTSOURCED
N=21

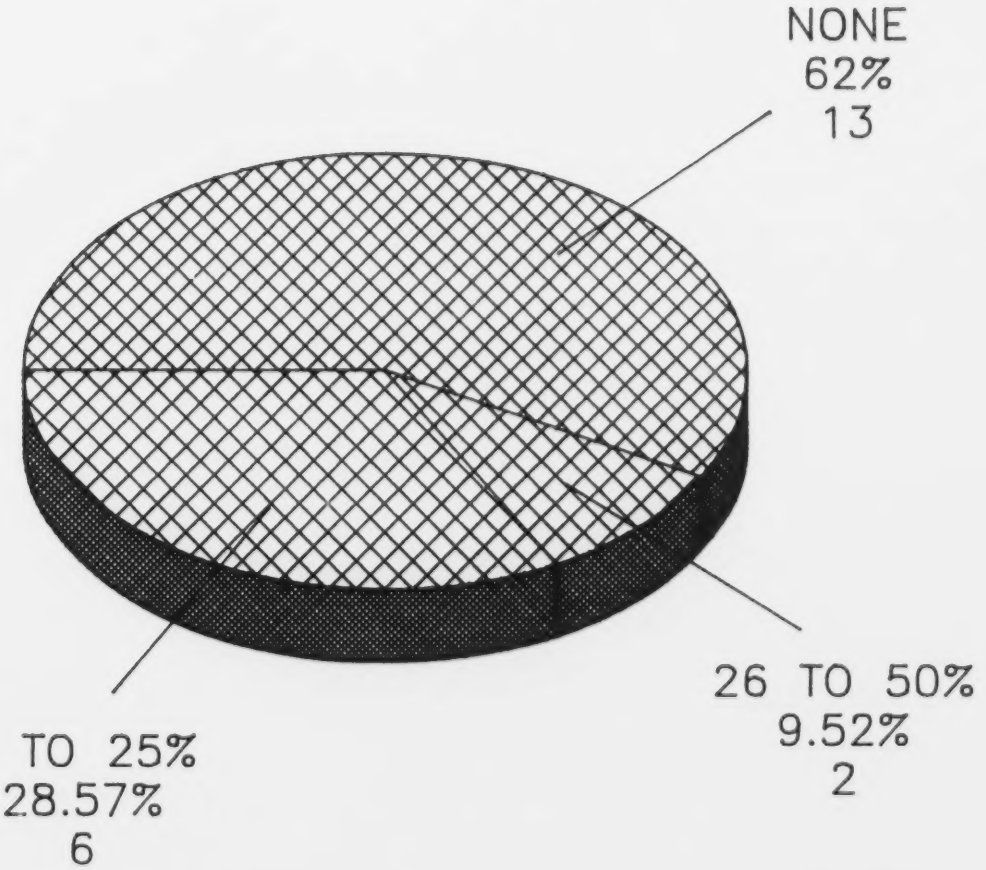


FIGURE 6

Irwin, 28

AMOUNT OF CADD BEING PERFORMED AS COMPARED TO MANUAL METHODS
N=21

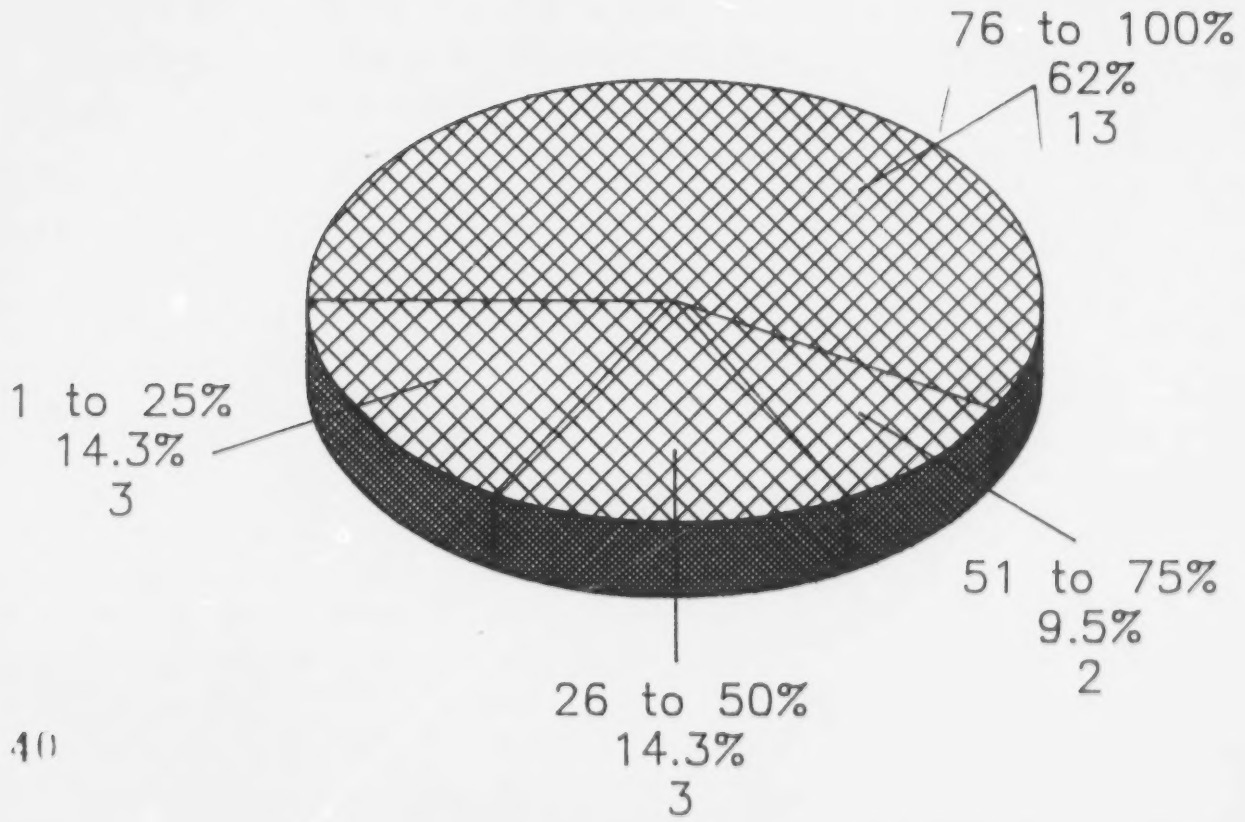


FIGURE 7

IIWIN, 29

What is the relationship between contract services and independent firms uses of CADD systems?

The two categories of respondents, contract services and independent firms were asked in question 9 to rate the extent to which CADD is being used and the need for inservice training for CADD. Percentages were calculated for each value-rated response, and they were compared by chi-square analysis. The results are shown in Table 4.

CHI-SQUARE ANALYSIS OF INDEPENDENT FIRMS COMPARED TO CONTRACT SERVICES RATINGS OF CADD USES AND INSERVICE NEEDS							
CADD USE	GROUP	ALWAYS	USUALLY	SOMETIMES	RARELY	NEVER	CHI-SQ
ELEC/HYDR/ PNEUM SCHEM	CONT.	33.3	16.7	16.7	33.3	0	79.28
	IND.	46.2	30.8	0	0	23.0	P>.001
2D DES/DRAFT	CONT.	40	40	20	0	0	35.08
	IND.	46.2	15.4	15.4	7.7	15.4	P>.001
3D DES/DRAFT	CONT.	20	20	0	20	40	41.68
	IND.	15.4	7.7	30.1	7.7	38.5	P>.001
PROPOSAL DRAWINGS	CONT.	20	40	40	0	0	30.34
	IND.	38.5	23.1	23.1	0	15.4	P>.001
BILLS OF MATERIAL	CONT.	0	60	0	20	20	55.34
	IND.	7.7	23.1	15.4	7.7	46.2	P>.001
SOLID MODELING	CONT.	20	20	0	0	60	26.98
	IND.	7.7	7.7	7.7	7.7	69.2	P>.001
ISOMETRIC DRAWINGS	CONT.	20	0	20	40	20	41.74
	IND.	7.7	23.1	23.1	15.4	30.1	P>.001
DIGITIZING DRAWINGS	CONT.	0	0	20	20	60	28.58
	IND.	0	7.7	0	23.1	69.2	P>.001
CIM/CAM/CNC	CONT.	0	0	0	40	60	69.81
	IND.	23.1	0	23.1	7.7	46.2	P>.001
INSERVICE NEED	GROUP	CRITICAL	VERY/NEC	NEC	SOME/NEC	UNNEC	CHI-SQ
ELEC/HYDR/ PNEUM SCHEM	CONT.	0	33.3	0	50	16.7	108.23
	IND.	30.1	7.7	30.1	7.7	23.1	P>.001
2D DES/DRAFT	CONT.	40	20	0	40	0	86.14
	IND.	38.5	15.4	30.1	0	15.4	P>.001
3D DES/DRAFT	CONT.	20	40	0	0	40	30.34
	IND.	38.5	23.1	15.4	0	23.1	P>.001
PROPOSAL DRAWINGS	CONT.	0	20	20	60	0	129.09
	IND.	38.5	7.7	30.1	0	23.1	P>.001
BILLS OF MATERIAL	CONT.	0	0	40	40	20	73.93
	IND.	23.1	7.7	15.4	7.7	46.2	P>.001
SOLID MODELING	CONT.	20	20	20	0	40	35.04
	IND.	23.1	15.4	23.1	23.1	15.4	P>.001
ISOMETRIC DRAWINGS	CONT.	20	0	20	20	40	59.67
	IND.	23.1	30.1	30.1	7.7	7.7	P>.001
DIGITIZING DRAWINGS	CONT.	0	0	0	40	60	60.60
	IND.	7.7	15.4	23.1	23.1	30.1	P>.001
CIM/CAM/CNC	CONT.	0	0	0	40	60	106.27
	IND.	38.5	0	23.1	0	38.5	P>.001

TABLE 4

MAJOR FINDINGS

1-2D design/drafting on average is rated the highest use of CADD, and digitizing drawings is rated the lowest use of CADD.

2-2D design/drafting on average is rated as having the highest need for inservice training for CADD, and digitizing drawings is rated the lowest need for training.

3-The most used microcomputer CADD software by the respondents is AutoCAD.

4-The most used mainframe CADD system by the respondents is Unigraphics.

5-Currently employed CADD operators acquired skills to operate CADD systems on the job or apprenticeships most often, and least often in a high school setting.

6-The highest level of education achieved by CADD user respondents was most often a junior college or associates degree.

7-The majority (13, 62%) of CADD users responding to the survey rated the percentage of CADD work being outsourced to contract services as NONE.

8-The amount of CADD being performed in comparison to manual procedures was rated by most of the respondents (13, 62%) as being 76 to 100% of work being done on CADD systems.

9-The chi-square analysis of the extent to which CADD is being used by independent firms and contract services shows $p<.0001$ levels of significance for all CADD uses.

The most obvious difference was shown in the electronic/ hydraulic/pneumatic schematic CADD use, (chi-squared =79.28), caused by the tendency of independent firms to mark the extreme answers "Always" and "Never" more frequently than contract firms.

10-Independent firms and contract services were also significantly different on the need for inservice training for CADD ($p<.0001$) for all CADD uses. The largest contrast, (chi-squared =129.09), was shown in the proposal drawing CADD use caused by the tendency for independent firms to rate the need for inservice critical or unnecessary more than contract services.

EXPLANATION OF FINDINGS

The findings listed previously can be explained by relating back to Table 1 and question 3, what is the primary product manufactured at your firm, which reveals that the majority of the respondents were manufacturing/design/ process engineering firms primarily producing automated assembly, testing, or CNC equipment. In this type of engineering firm the CADD work is mostly assembly drawings and details which do not usually require 3D or solid modeling. Although, the number 2 ranked need for inservice was rated as 3D design/drafting, which means even though 3D was rated as being rarely used it was rated as being necessary to learn by most respondents. To do complicated product design 3D design and solid modeling is becoming necessary, and the companies recognize the need for

inservice of their CADD users in this area.

AutoCAD is a very popular CADD software in the United States for mechanical and architectural drawing. AutoCAD has 3D capabilities, and many software programs are written to be used with AutoCAD to tailor it for special applications. Unigraphics is the mainframe system that General Motors has adopted as their CADD standard throughout their plants so many contract services also have Unigraphics stations.

Since CADD is fairly new in the drafting industry the educational institutions are just starting to catch up to industry. The most used method of training by CADD users being on the job or apprenticeships shows that in the past the educational institutions did not have the facilities to teach CADD. This trend may change in the future with the emergence of more CADD training centers in the Saginaw area. It should be mentioned here that a good amount of the respondents (23.4%) did obtain CADD training in junior college or associate degree programs.

The largest group of CADD users was by far the junior college or associate degree program respondents (36.9%) who have an advantage over an apprentice, trade-tech. school, or high school graduate simply because of the greater amount of educational training. The college or university bachelors degree graduate is usually an engineer who does less CADD work and more customer relations, research and development.

A small percentage of firms admit in the survey to outsourcing some CADD work, but independent firms must

contract out enough work to keep the contract services in business. The majority of the firms responded that they outsourced NONE, but half of those respondents were contract firms themselves. It is very unlikely that a contract firm would subcontract out work unless they were very busy.

The major finding that 62% of the respondents believe that CADD is used 76 to 100% of the time over manual methods is because of the time savings, accuracy, record keeping, etc.. The reason all respondents did not answer in this category is that many companies have not totally switched over to CADD yet, and manual drafting still has its own merits especially for a one time used design.

The contrast between independent firms and contract services evidenced by the tendency for independent firms to answer "Always" or "Never" more often than contract services shows a difference in the character of the work. A contract service receives a variety of diverse jobs, and an independent firm usually has one type of standard product which they manufacture. For instance, an independent firm may always use CADD for electronic schematics, but a contract service may only get electronic schematics sometimes. The need for training follows the same tendencies for the same reasons as stated above.

RELATED TO LITERATURE

The questionnaire findings as related to the earlier findings from research fall into the same three categories:

1.Types of CADD systems

2.The categories of CADD users

3.The symbiotic relationship between industry and education providing CADD training.

The type of systems chosen for the survey were accurate, because not many respondents had to choose the "Other" option and specify their system. The number of respondents who classified themselves as architectural/civil firms, even after attempts were made to narrow the list of subjects to mechanical firms only, substantiates the research that there is a large potential for CADD in the architectural/civil and structural engineering fields. The levels of CADD user also paralleled the literature research, because respondents classified CADD users in 9 different categories from CADD drafters to programmers which could be classified as in the literature research as system designers, specified users, and naive users. The findings did not reveal a partnership between employers and training facilities as illustrated in the research, but a large percentage (23.4%) were trained on CADD in junior college or an associate degree program. So, a link may exist between some companies and junior colleges, but this survey did not address that issue.

Finally, respondents were asked if they were interested in receiving a copy of the results of the study. If they checked the space a summary of the study was sent to them.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

CADD is defined as computer aided design and drafting performed on either a microcompter or mainframe system: The purpose of this study was to identify the extent to which CADD is being used in local businesses.

To obtain answers to the questions of this study, (as stated in Chapter I), a survey questionnaire was used. This instrument was administered to drafter and designer employers who use CADD systems to design and detail mechanical and machine tool products.

Major Findings

1-2D design/drafting on average is rated the highest use of CADD, and digitizing drawings is rated the lowest use of CADD.

2-2D design/drafting on average is rated as having the highest need for inservice training for CADD, and digitizing drawings is rated the lowest need for training.

3-The most used microcomputer CADD software by the respondents is AutoCAD.

4-The most used mainframe CADD system by the respondents is Unigraphics.

5-Currently employed CADD operators acquired skills to operate CADD systems on the job or apprenticeships most often, and least often in a high school setting.

6-The highest level of education achieved by CADD user respondents was most often a junior college or associates degree.

7-The majority (13, 62%) of CADD users responding to the survey rated the percentage of CADD work being outsourced to contract services as NONE.

8-The amount of CADD being performed in comparison to manual procedures was rated by most of the respondents (13, 62%) as being 76 to 100% of work being done on CADD systems.

9-The chi-square analysis of the extent to which CADD is being used by independent firms and contract services shows $p<.0001$ levels of significance for all CADD uses. The most obvious difference was shown in the electronic/ hydraulic/pneumatic schematic CADD use, (chi-squared =79.28),caused by the tendency of independent firms to mark the extreme answers "Always" and "Never" more frequently than contract firms.

10-Independent firms and contract services were also significantly different on the need for inservice training for CADD ($p<.0001$) for all CADD uses. The largest contrast, (chi-squared =129.09), was shown in the proposal drawing CADD use caused by the tendency for independent firms to rate the need for inservice critical or unnecessary more than contract services.

Conclusions

AutoCAD is a viable software to be using in a educational setting for teaching mechanical drafting to

students in the Saginaw Valley area. Being exposed to a CADD system of any kind gives a person an edge in the competitive job market, but being trained on the specific system which the company uses is a tremendous advantage. AutoCAD is by far the preferred microcomputer CADD software by the respondents of this survey.

Mainframe CADD systems are far beyond the budgets of most vocational schools and high schools. Although, Unigraphics is a mainframe CADD system which has many design capabilities and would be a good alternative for a junior college or college in addition to an AutoCAD system.

CADD systems are being used for all types of applications and to various extent by the respondents of this survey. Knowing how to operate a computer and manipulate the software is not sufficient enough to be a CADD user in the Saginaw area. To perform 2D design/drafting, (the most often use of CADD by most of the respondents), a CADD user needs technical information beyond knowledge of CADD system use. In a high school setting in the traditional one hour block there is only time to be instructed in the use of the CADD software. In a junior college or high school vocational training, (2 1/2 hours a day), in mechanical drafting there is sufficient time to deliver technical information as well as learning the CADD system. Knowing how to operate a CADD system only will qualify a person to perform digitizing drawings, (tracing a manually done drawing into the computer), which was rated as

never being used by most of the respondents.

Most of the need for inservice training in CADD being in the areas of 2D and 3D design/drafting combined with the finding that most currently employed CADD operators acquired skills to operate CADD systems by on the job training or apprenticeships leads this researcher to believe that continued training is necessary for currently employed CADD users to stay up to date with the latest software changes. For instance, in December of 1991 AutoCAD made available their latest revision of the software, (release 11.0), and most companies upgrade their systems to stay relevant. The Averill Career Opportunities Center in Saginaw offers adult education courses in AutoCAD in the evening as well as Delta and Mott Community Colleges, which give the opportunity for current CADD users to retrain. Companies who have apprenticeships in place for their employees should include an AutoCAD or Unigraphics course as a requirement.

Most CADD users who responded to the survey had achieved at least an associates degree level of education, which means articulation between high schools, vocational schools, and higher education should be encouraged. It would be best for a student if they could earn their degree earlier by passing out of a college level class in "Introduction to CADD" if they had two years of vocational CADD in high school. Since the majority of CADD users have earned higher education degrees, then high school vocational drafting courses must train students for both employment and

further education.

With 76 to 100% of drafting and design being performed on computer instead of using manual methods there is a higher demand for drafters with CADD skills instead of manual skills. Companies switching over from manual methods to CADD will require retraining for their employees. This researcher suggests a structured course in a CADD system instead of OJT or self teaching, because a trained expert in teaching CADD can solve problems from experience which would be major stumbling blocks otherwise.

The relationship that exists between contract services and independent firms uses of CADD is significantly different in the extent to which they use their system, but on average the top three uses were by the two groups were identical. The contract services use their systems for a more wide variety of CADD uses than independent services. Finally, CADD users for contract services should be skilled on variety of CADD systems, because they may have to do contract work for a number of different companies using that companies CADD system.

Limitations

The major limitation of this study is one which is common to many survey studies. That limitation is the unreliability and generalizing from the small sample of 27 respondents which 21 were actually used in the presentation and analysis of data.

The second limitation is in the number of respondents

in the category of manufacturing/design/process engineering (13) being much larger than for contract services (6). A more accurate crossection of the contract services would have been achieved with a larger sampling.

A third limitation relates to the questionnaire. Question 8 pertaining to educational training of CADD users should have had a more descriptive explanation, because 3 of the respondents did not return this part of the survey. Also, in question 8 another source of CADD training to choose from should have been "Vendor training".

Theoretical Interpretations

A formal link should be made between the business and industry companies which use the same type of CADD system as the educational institution's drafting department. The companies should then adopt the program by offering exploratory experience and co-op sites for students, and in return receive training for their current CADD users. This "Adopt a Program" approach would give opportunities for students to enter the work force and also update skills of the present workforce.

Recommendations for Future Study

Future studies should be concentrated on the area of architectural/civil engineering companies using CADD systems in the Saginaw area. There may be a need for more CADD users with the theoretical background necessary for doing that type of work just as much or more than mechanical drafting. The Saginaw public school system may be interested in adding

a vocational course in architectural/civil engineering at the Averill Career Opportunities Center with information from such a survey.

APPENDIX A

QUESTIONAIRE

CADD SURVEY

DIRECTIONS: Please respond to each of the below items as indicated. Thank you.

1. Position of the individual responding to survey: _____

2. Which of the below best describes your firm?

   a. _____ Manufacturing/design/process engineering
   b. _____ Contract design/drafting service
   c. _____ Other (specify) _____

3. If a manufacturing firm, what is (are) your primary product(s)

   _____

4. Into which of the below categories does your firm fall?

   a. ____ Architectural/civil engineering
   b. ____ Mechanical/machine tool engineering
   c. ____ Other (specify) _____

5. What type of CADD system(s) and how many stations of each are being used at your firm?

   Microcomputer Systems

Type of System	Number of Stations
a. ____ AutoCAD	____
b. ____ VersaCAD	____
c. ____ IBMCAD	____
d. ____ Other (specify) _____	____

   Mainframe Systems

Type of System	Number of Stations
e. ____ Applicon	____
f. ____ Inergraph	____
g. ____ IBM CADDAM	____
h. ____ Unigraphics	____
i. ____ Other (specify) _____	____

6. What percentage of your computer aided design and drafting work is being outsourced to contractors each year?

   a. ___ None b. ___ 1 to 25% c. ___ 26 to 50% d. ___ 51 to 75% e. ___ 76 to 100%

7. What percentage of your design and drafting is performed using computer aided drafting and design systems as compared to manual drafting and design procedures?

   a. ___ None b. ___ 1 to 25% c. ___ 26 to 50% d. ___ 51 to 75% e. ___ 76 to 100%

8. Thank you for completing this survey, and if you are interested in receiving a copy of the results please check this space. ____

8. INFORMATION ABOUT COMPUTER AIDED DRAFTERS & DESIGNERS

A. OCCUPATIONS IN YOUR FIRM	B. NO. PRESENTLY EMPLOYED	C. CADD TRAINING						D. LEVEL OF EDUCATION					
JOB TITLES PLEASE LIST EACH DIFFERENT OCCUPATION IN YOUR FIRM OR AGENCY. ADD DESCRIPTIVE WORDS, CLASSES, OR GRADES THAT WILL CLARIFY THE NATURE OF THE JOB.	NUMBER TOTAL NUMBER OF PERSONS PRESENTLY EMPLOYED IN EACH OCCUPATION LISTED TOTAL	CHECK MAJOR SOURCE OR TYPE OF TRAINING WHERE EMPLOYEES AQUIRED SKILLS NEEDED TO OPERATE A CADD SYSTEM						HIGHEST LEVEL OF EDUCATION ACHIEVED					
		HIGH SCHOOL	O/T OR APPRENTICESHIP	TRADE TECHNICAL SCHOOL	JR. COLLEGE ASSOCIATES DEGREE	COLLEGE OR UNIVERSITY BACHELORS DEGREE	OTHER	HIGH SCHOOL	O/T OR APPRENTICESHIP	TRADE TECHNICAL SCHOOL	JR. COLLEGE ASSOCIATES DEGREE	COLLEGE OR UNIVERSITY BACHELOR'S DEGREE	OTHER
EXAMP. CAD DRAFTER	3	1			2			1			1	1	
58												59	

CREATED ON AUTOCAD
RELEASE 11 SOFTWARE

9. *Please rate the CADD uses below in regards to the statements.. Place a check to indicate your choice.*

	EXTENT TO WHICH CADD IS BEING USED 1 Always 2 Usually 3 Sometimes 4 Rarely 5 Never					CADD USES	NEED FOR INSERVICE TRAINING FOR CADD 1 Critical 2 Very necessary 3 Necessary 4 Somewhat necessary 5 Unnecessary				
	1	2	3	4	5		1	2	3	4	5
a	—	—	—	—	—	ELECTRONIC/HYDRAULIC PNEUMATIC SCHEMATICS	—	—	—	—	—
b	—	—	—	—	—	2D DESIGN/DRAFTING	—	—	—	—	—
c	—	—	—	—	—	3D DESIGN/DRAFTING	—	—	—	—	—
d	—	—	—	—	—	PROPOSAL DRAWINGS	—	—	—	—	—
e	—	—	—	—	—	BILLS OF MATERIAL	—	—	—	—	—
f	—	—	—	—	—	SOLID MODELING	—	—	—	—	—
g	—	—	—	—	—	ISOMETRIC DRAWINGS	—	—	—	—	—
h	—	—	—	—	—	DIGITIZING DRAWINGS	—	—	—	—	—
i	—	—	—	—	—	CIM/CAM/CNC	—	—	—	—	—

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APPENDIX B

LETTER OF TRANSMITTAL

Career Opportunities Center

School District of the City of Saginaw
Averill Career Opportunities Center
2102 Weiss Street • Saginaw, Michigan 48602 • (517) 797-4836 • FAX (517) 797-4843

Julie A. Walker, Director

December 3, 1991

Averill Career Opportunities Center
John Irwin
CADD Manager-User
2102 Weiss
Saginaw, MI 48602

Dear Mr. Irwin:

To help fulfill our mission to provide technologically competent workers for business and industry, we in education need to know about the marketplace our students face. My area of emphasis is Drafting, specifically CADD. Within that area, Averill Career Opportunity Center attempts to provide training on equipment which is compatible with that used in industry and provide students with as much information as possible about their future working environment.

As a part of the requirements for completion of a Master of Science in Occupational Education degree at Ferris State University, I am conducting a survey of CADD users and managers in the Saginaw Valley area. This survey will help me to realize the goal of working with my students so that the training they receive is in keeping with industry requirements.

Your cooperation in completing the enclosed survey to assist me and my students in achieving that goal is much appreciated. Please complete each item in the survey to the best of your knowledge and ability. Depending on the size and extent of your CADD installations, it should take no longer than 20 - 30 minutes to complete. All replies will be held in confidence and all data will be aggregated in the final report so that no individual or firm can be identified. Your survey is coded by number only for purposes of follow-up.

Please call me at (517)753-0694 or (517)797-4836 you have any questions or concerns regarding the survey.

Thank you in advance for your time and effort.

Yours truly,

John Irwin
CADD Instructor
Averill Career Opportunity Center

APPENDIX C

FOLLOW-UP LETTER

Career Opportunities Center

School District of the City of Saginaw
Averill Career Opportunities Center
2102 Weiss Street • Saginaw, Michigan 48602 • (517) 797-4836 • FAX (517) 797-4843

Julie A. Walker, Director

December 18, 1991

Averill Career Opportunities Center
John Irwin
2102 Weiss
Saginaw, MI 48602

Dear Mr. Irwin:

A few weeks ago I sent you a questionnaire asking for information about your Engineering Department Computer Aided Design and Drafting uses and Inservice needs. If your reply to the questionnaire is in the mail, please ignore this letter. However, if you have not completed and returned the questionnaire please do so now. This information will be used to help make decisions on what type of training will be addressed at the Averill Career Opportunities Center.

I have enclosed a duplicate copy of the questionnaire. Your completion of the questionnaire is essential to achieve any meaningful results for me to base conclusions. A postage paid envelope is included with the questionnaire for your reply.

Remember, your responses will remain anonymous and confidential. The results of the survey will be made available to you by checking the appropriate box.

I would be happy to answer any questions you might have. Please call at (517)753-0694 or (517)797-4836. Thank you for your cooperation.

Best regards,

John Irwin
CADD Instructor
Averill Career Opportunities Center

Notes

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[3] Paul Ross Wallach and Dean Chowenhill, page 9.

[4] James R. Kimmey, A Prototype of CAD/CAM Education in the Community College (ERIC, ED 261 716, 1986), 5.

[5] Nancy V. Snyder, Revision of Electro-Mechanical Drafting Program to Include CAD/D (Computer-Aided Drafting/Design). Final Report (ERIC, ED 255 648, 1984), 1.

[6] Raphael Kaplinsky, Computer-Aided Design: Electronics, Comparative Advantage and Development (New York: Macmillan Publishing Co., Inc., 1982), 41.

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[9] P.C. Ingham, Computer Aided Design in FE. Some Suggestions on the Inclusion of CAD Topics in Mechanical Engineering Courses. An Occasional Paper (ERIC, ED 224 999, 1982), 15.

[10] P.C. Ingham, page 16.

[11] Anthony P. Carnevale et al., Train[illegible] the Technical

Work Force (California and Oxford: Jossey-Bass Inc., Publishers, 1990), 7.

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[13] Thomas J. Lazear, "CAD Training in Industry and Education," Technological-Horizons-in-Education 11 (Jan. 1984): 138.

[14] Steve Chi Yin Yuen, "Incorporating CAD Instruction into the Drafting Curriculum," Technology-Teacher 50 (Dec. 1990): 30.

[15] Anthony P. Carnevale, page 57.

[16] James R. Kimmey, page 4.

[17] Anthony P. Carnevale, page 57.

[18] Nancy V. Snyder, page 1.

[19] Anthony P. Carnevale et al., page 58.

[20] Lansing Community College, "Employment Placement Services Survey," photocopy.

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